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WM. A. TAYLOR, Chief

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COMMERCIAL UTILIZATION OF WASTE SEED FROM THE TOMATO PULPING INDUSTRY.

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PROFITABLE UTILIZATION OF WASTE MATERIALS.

The utilization of waste materials from the canning or packing of certain classes of agricultural products is at present commanding considerable attention in connection with the possibility of reducing the waste of commodities of commercial importance. The nature of the waste material varies, of course, with the type of products which are canned or packed.

In the manufacture of the various tomato products for which there are very extensive packing operations in the United States there occurs a waste, consisting of seeds and skins, which possesses inherent possibilities from the standpoint of profitable utilization.[1] At present this material is not being utilized, possibly because of lack of knowledge regarding the proper methods of procedure attending a well-directed commercial project of this character, and

[1] Rabak, Frank. The utilization of waste tomato seeds and skins. U. S. Dept. Agr. Bul. 632. 15 p. 1917.

possibly also because of lack of information bearing on the probable returns. These are important factors which underlie the establishment of an industry of this kind and will be given careful consideration in this bulletin.

NATURE AND SOURCE OF TOMATO WASTE.

The largest proportion of waste which accumulates in the tomato-packing industry results from the pulping operations connected with the manufacture of catsup, pulp, soup, paste, and sauce. The waste as it occurs in these pulping plants consists of a wet mass of seeds and skins (fig. 1). Only the seeds, however, will here be considered,

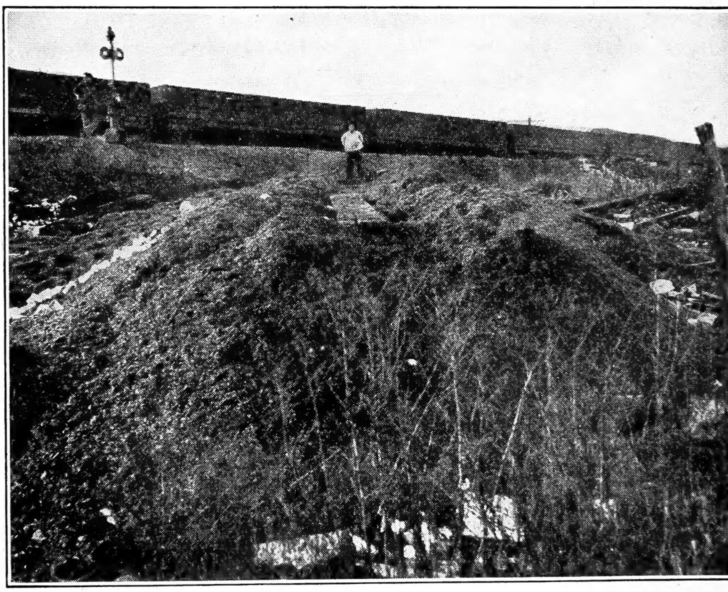

FIG. 1.—Tomato-seed waste at a pulping plant.

since this is the portion which possesses the greatest value as a source of commercial products.

DISTRIBUTION AND QUANTITY OF TOMATOES PULPED ANNUALLY.

The tomato pulping stations are scattered over a large area, including Maryland, Delaware, New Jersey, New York, Ohio, and Indiana. Since these States comprise a continuous geographical series, the investigation has been restricted entirely to this area.

In this connection it may be of interest to point out the size of tomato pulping stations. Because of the perishable character of the raw material it is necessary that the stations be located in tomato-growing localities, in order that only a minimum period of time may

elapse between the picking of the fruit and the preparation of the products. This has led to the erection of a number of pulping stations, most of which are comparatively small from the standpoint of seed produced. A station which pulps 5,000 baskets (of five-eighths of a bushel each) of tomatoes in a 10-hour day is considered a large plant. Many, however, handle only 1,000 baskets. Thus, it is evident that any utilization project must be concerned with the larger stations located at readily accessible points.

Approximately 205,000 tons of tomatoes are pulped annually at the larger stations in what might be called the eastern and middle-western tomato belts, distributed by States as shown in Table I.

TABLE I.—*Distribution and quantity of tomatoes pulped annually at the larger pulping stations, with the tonnage of dry seed produced.*

State.	Estimated product (tons).		State.	Estimated product (tons).	
	Tomatoes pulped.	Waste seed.		Tomatoes pulped.	Waste seed.
Delaware	6,600	33	New Jersey	63,000	315
Illinois	12,300	61	New York	10,090	50
Indiana	69,000	345	Ohio	8,090	40
Kentucky	948	5	Pennsylvania	7,400	37
Maryland	26,100	130			
Michigan	2,000	10	Total	205,528	1,026

The quantity of seed obtainable from raw tomatoes was ascertained in connection with field work carried on in different parts of the country and from reports of firms now operating on seed recovery, thus eliminating the uncertainty of estimates as to the tonnage of waste seed available. From determinations made with Maryland fruit it was found that seed reduced to a 10 per cent moisture basis constituted about 0.6 per cent of the normal tomatoes. Other determinations on middle-western tomatoes showed from 0.4 to 0.5 per cent. Firms operating on seed recovery for planting purposes report about 0.58 per cent. One-half of 1 per cent has, therefore, been adopted as representing the average percentage of seed available. Hence, each ton of tomatoes pulped should yield about 10 pounds of dry seed. These figures, of course, refer to seed practically free from skins, with a moisture content of 10 per cent, such as would be produced commercially by the recovery methods to be described later.

Table II records the tonnage of tomatoes pulped over a period of five years, 1914 to 1918, inclusive, only the data actually reported being included. The figures, as here given, refer to the larger pulping stations, situated at points readily accessible for railroad transportation. Figures from the smaller producing stations have not been included, because of the increased cost which would be involved in assembling small quantities of material.

TABLE II.—*Quantity of tomatoes pulped from 1914 to 1918, inclusive, in the larger plants in the eastern and middle-western tomato belts.*

State.	Production (tons).				
	1914	1915	1916	1917	1918
Delaware	450	1,550	4,650	6,540	5,050
Illinois		3,200	11,300	11,300	10,600
Indiana	13,677	11,637	19,736	22,837	46,077
Kentucky			1,000	878	967
Maryland	6,000	5,300	7,556	29,489	29,165
New Jersey	12,681	9,338	14,570	16,362	19,323
New York	12,800	7,636	10,215	5,962	14,093
Ohio	12,689	12,674	9,412	4,639	9,961
Pennsylvania	10,400	5,500	9,000	4,040	4,949
Total	68,697	56,835	87,439	102,047	140,185

Supplementing the figures given in Tables I and II, there is presented in Table III the entire production of tomatoes for soups, pulp, purees, etc., in two years, 1917 and 1918, as published by the Bureau of Crop Estimates on January 17, 1919.

TABLE III.—*Quantity of tomatoes used for soups, pulp, purees, etc., in the eastern and middle-western tomato belts for the years 1917 and 1918.*

State.	Total production (tons).		State.	Total production (tons).	
	1917	1918		1917	1918
Delaware	14,564	37,870	New Jersey	69,461	110,209
Illinois	3,137	7,494	New York	10,531	37,880
Indiana	60,947	148,225	Ohio	10,531	25,001
Kentucky	2,017	4,309	Pennsylvania	3,362	8,024
Maryland	19,083	26,083			
Michigan	3,137	7,515	Total	187,770	412,610

QUANTITY OF SEED AVAILABLE.

Since one-half of 1 per cent is adopted as the yield of dry seed from whole ripe tomatoes, the total quantity available, as shown in Table I, is 1,026 tons. This tonnage is based on the output of pulp from only the largest manufacturers in the States specified. By calculation from the figures given in Table III for 1918, it is found that a total of 2,063 tons of seed is available as the output of all the pulping plants in the eastern and middle-western tomato belts.

COMMERCIAL PRODUCTS OBTAINABLE FROM TOMATO SEED.

By proper treatment tomato seeds may be made to yield two important commercial products—namely, fixed oil and press cake, or meal. In order to obtain these products it is necessary that a certain procedure be followed, and the purpose of this bulletin is to describe in detail the handling of the material from the time the wet waste

leaves the pulping machine until the finished product is ready for the market. The accompanying diagram (fig. 2) shows the reduction of waste from the tomato pulping industry.

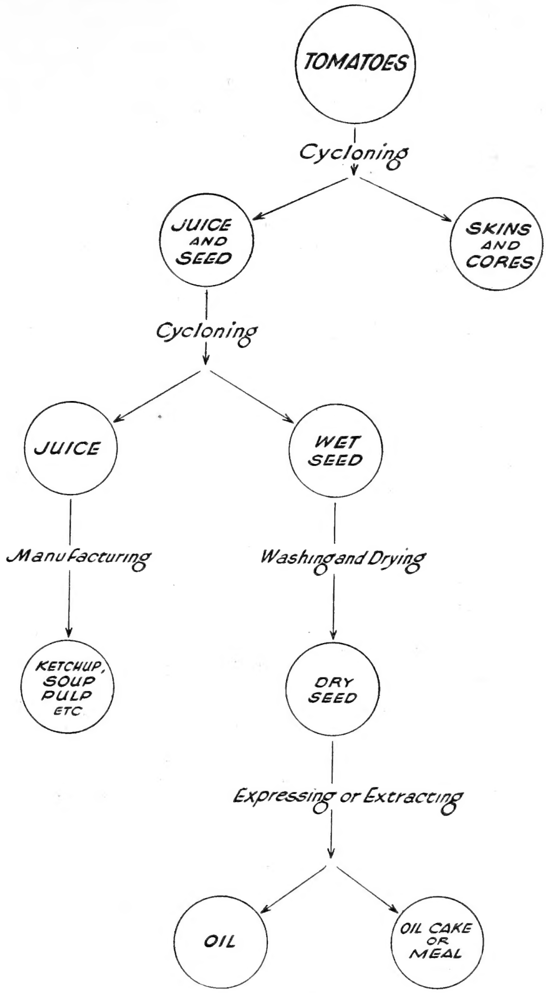

FIG. 2.—Diagram showing the reduction of waste from the tomato pulping industry.

PROCEDURE IN HANDLING TOMATO WASTE.

Two important steps are involved in preparing tomato seed for oil production: The separation of the seed from the wet waste material and the drying of the seed.

SEPARATING THE SEED FROM THE WASTE MATERIAL.

The wet mass of seeds and skins as it comes from the pulping operations is known as "cyclone waste,"[2] and several methods may be employed for separating the seeds from this waste. The common practice where only small quantities of seed intended for planting purposes are involved consists in suspending the waste in several volumes of water and agitating the mass. The skins, being lighter than the seed, have a tendency to float, while the seeds and cores sink.

In large-scale operations[3] the waste is discharged into a long trough provided with a false bottom, the mesh of which is of a size which

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[2] So called from the name of the pulping machine.

[3] Huelsen [W. A,] Tomato-seed experiment. *In* The Canner, v. 47, no. 24 (no. 1246), p. 42. 1918

allows only the seed to fall through. A slow stream of water enters the trough at the upper end and overflows at the lower end. The waste is continuously introduced with the water, thoroughly agitated with it, and carried slowly forward. In this movement the mass becomes disintegrated, allowing the seed to settle slowly, while the skins are carried forward and discharged by the overflow or skimmed off by workmen. When the seed accumulates above a certain point in the trough the operation is discontinued and the trough dumped. The seed is then placed in muslin bags and centrifuged for about half an hour, to remove the excess moisture, and then dried. One disadvantage of this method lies in the fact that it requires the entire time of several workmen. Such practice pays when the seed is intended for planting purposes, in which case it brings a comparatively high price, but if intended for crushing for oil it is not profitable.

Another method which has been developed on a commercial scale consists in dumping the waste into a large funnel-shaped receiver, 4 to 5 feet in diameter at the top and possibly as deep, filled with water which has been given a circulatory motion by impinging several streams of water set at small angles to the surface. As it is dumped into the vessel the waste is disintegrated by the swirling motion. The seeds sink, while the skins are carried over the top in a continuous overflow. When a large quantity of seed has accumulated the action is stopped, the vessel tilted, and the excess water poured off. The container is then restored to its original position and the seed dumped by a gate valve in the bottom. It is estimated that by this method about 90 per cent of the seed is recovered. Two men operate the entire recovery equipment, including the seed separation and the drying units. Such a machine is large enough to handle all the waste from a 5,000-basket plant.

In Italy the waste is first dried and the seed then fanned out. The advantage of this method is that the seed is rendered available by one operation. The disadvantage, however, is that some of the seeds are lost because, in drying, the particles of skin curl back and inclose many of them. It is not believed that any amount of grinding and fanning can recover all or nearly all the seed, although no figures are available as to the efficiency of such operations.

The most practical method for separating the seed from the waste is to make the separation in the original cycloning operation used in making the pulp, thus entailing only one handling. The operation is continuous, with no intermittent discharge and with no extra labor. To all who operate the ordinary cyclone pulping machines (fig. 3) it is apparent that if the perforations of the screen are just large enough to permit the passage of the seeds, these with the pulp will flow out of the machine in a continuous stream, while the cores and skins will be discharged through the gate of the machine as usual.

A 5-mesh woven screen made of No. 12 wire has been found very satisfactory. There is a greater tendency for the small pieces of skin to go through the meshes with the seed than for the seed to remain back with the skins; in other words, the operation is in favor of the seed. The stream of pulp and seed is pumped into an adjoining cyclone provided with an ordinary breaker screen (about 20-mesh),

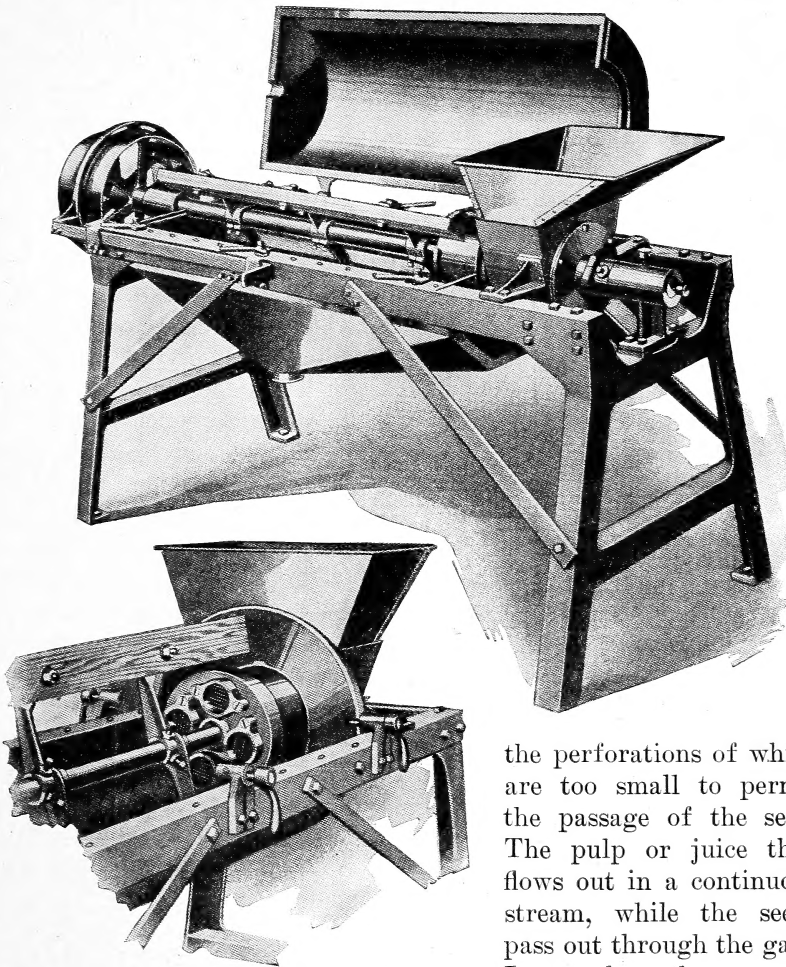

FIG. 3.—A cyclone pulping machine.

the perforations of which are too small to permit the passage of the seed. The pulp or juice then flows out in a continuous stream, while the seeds pass out through the gate. Inasmuch as the two machines are placed together, preferably one behind the other, and one man operates both, it follows that this operation necessitates practically no increase in labor and is continuous and efficient. Experience with this method for more than two seasons at the Arlington Experimental Farm near Washington, D. C., confirms the conclusions as to its effectiveness.

A double cyclone is now being manufactured which separates the seeds from the skins and cores in one operation.

DRYING THE SEED.

Before the seed obtained from the operations just described is in condition for drying, it is preferable that it be washed and the excess moisture removed. As the seed emerges from the cyclone it is covered with a mucilaginous, slimy coating, and when placed in rotary driers in this condition it sticks to the drying surfaces. This coating also prevents satisfactory treatment in the preliminary removal of water. It has been found that satisfactory washing can be accomplished by suspending the seed in a stream of hot water and cycloning it out of the mixture by using the ordinary breaker cyclones. In practice this washing is done as follows: The seed is thrown into a funnel set in the inlet part of a centrifugal pump, while a stream of hot water, likewise directed into the funnel, carries the seed with it down into the pump, where the churning action of the rotor breaks up the clumps of seed, suspending each particle separately and discharging the whole mass more or less homogeneously into the washing cyclone. The seed is discharged through the gate quite clean and bright.

Cyclone waste as it is usually produced contains about 80 per cent of water, while the seed contains from 65 to 70 per cent. One difficulty in drying material with such a high moisture content is the cost of the operation. To economize in this respect and at the same time shorten the period of drying, several methods of moisture reduction may be employed.

A considerable proportion of the excess moisture can be removed by pressure. For this purpose small hydraulic presses of the type used for pressing out apple or grape juice may be used. Cloths are laid on racks, the seed is placed thereon, and the edges of the cloths are folded over, thus forming a cake. Several of these, one above the other, are placed in the press and hydraulic pressure applied. From 10 to 15 per cent of moisture can be removed by such treatment. A small press may have a capacity of about 400 pounds of wet seed an hour.

Moisture reduction by centrifuging has also been tried. In this method [4] the seed is placed in a bag and whirled, as in the ordinary type of laundry centrifuge. The use of a bag prevents the packing of the seed in the machine and facilitates emptying. The moisture content of seed, which originally was about 55 per cent, was found to be reduced to about 51 per cent. A centrifuge of ordinary size (about 3 feet) will handle approximately 600 pounds of seed an hour,

[4] Huelsen [W. A.], 1918. Op. cit., p. 42.

depending, of course, on the size and duration of the cycle. It will be noted that the above methods are not continuous and that they require the entire attention of the operator.

A moisture expeller (figs. 4 and 5) has been successfully applied in this operation. The machine is essentially similar to an oil expeller, consisting of a horizontal barrel composed of bars bolted together, along the longitudinal axis of which rotates a screw. This latter carriers the charge of wet seed forward and discharges it over a cone in the outlet of the barrel. By adjusting this cone in the throat of the barrel the degree of pressure, and consequently the extent of moisture reduction, can be regulated.

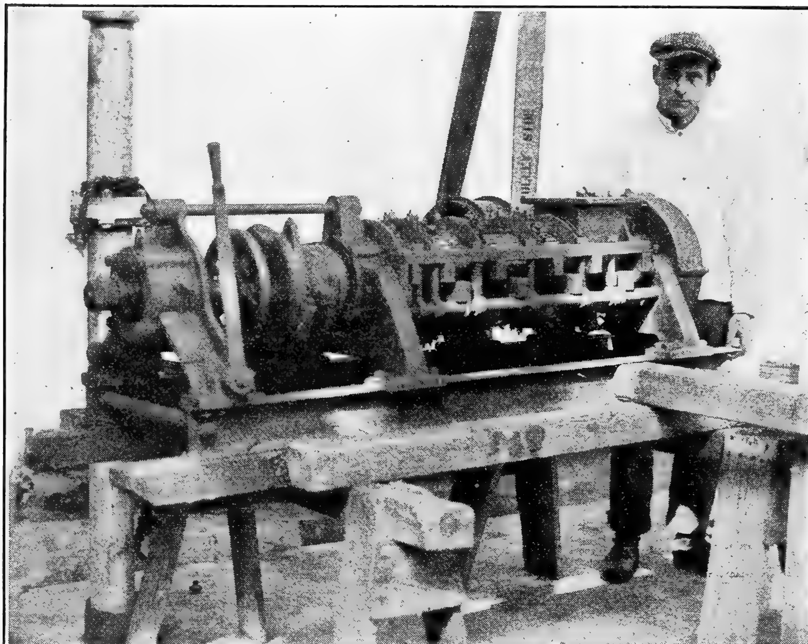

FIG. 4.—An experimental moisture expeller; Closed.

The machine does not operate on unwashed seed, as the slippery character of the latter causes it merely to churn. It is absolutely necessary that the seed be denuded of this coating material, and preferably pressed hot. All of this can be accomplished, of course, by washing the seed in hot water and pressing it immediately. By such procedure the moisture content can be reduced from 65 to about 52 per cent. The operation is continuous and does not need the constant attention of the operator; in fact, after being adjusted at the beginning of the run it operates without further change, except possibly a slight adjustment from time to time because of the varying character of the seed. Among its other advantages is the fact that owing

to the spongy character of the seed it emerges from the machine in a light, puffy condition, which obviates the necessity for grinding. Expellers of this type are manufactured in three commercial sizes, handling 400, 800, and 1,600 pounds of raw material an hour, with a power consumption of 5, $7\frac{1}{2}$, and 10 horsepower, respectively. Many of the seeds are bruised and torn, which would render them unsatisfactory for planting purposes, but the operation is quite satisfactory for reducing the moisture in seed intended for oil, because for this purpose such bruising is immaterial.

Drying is one of the most important processes in the successful and economical handling of the seed. Various types of machines for this operation are on the market. These may be classed under two general heads, tray driers and rotary driers.

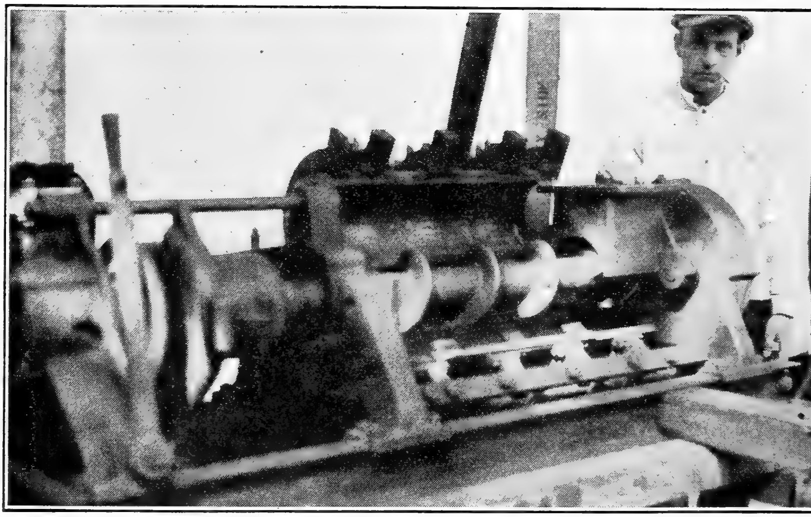

FIG. 5.—An experimental moisture expeller: Open.

The tray drier is most frequently employed for drying tomato seed intended for planting purposes. The seed, freed from as much water as can readily be drained off or as can be removed by slight pressure in some form of press, is spread out on trays in layers approximately one-half to 1 inch in depth and subjected to a slow current of warm air. In some cases no artificial heat whatever is imparted to the air current, the lack of heat being made up by greatly increasing the volume of air passed over the seed, which is protected from being blown away by placing a screen over the layers.

It is claimed that this treatment insures a high percentage of germination and is therefore perfectly feasible when the seed is intended for planting purposes; but for seed intended for oil extraction it is too expensive, since it involves a greater initial cost for

equipment because of the necessarily increased size of the air blower and the consequent power required for operating it.

A drier which can be satisfactorily used for handling tomato seed for oil extraction is a tunnel drier described in Farmers' Bulletin 984, United States Department of Agriculture (fig. 6). An adaptation of this form of drier for handling the quantities of seed produced by a plant pulping 1,000 baskets of tomatoes a day is a rectangular box 10 feet long, 2 feet wide, and 6 feet high. One end rests upon the floor (fig. 6, left), and the other end is raised $2\frac{1}{2}$ feet above the floor level by increasing the length of the studding. This gives the floor and ceiling of the box a uniform slope of 3 inches per foot of

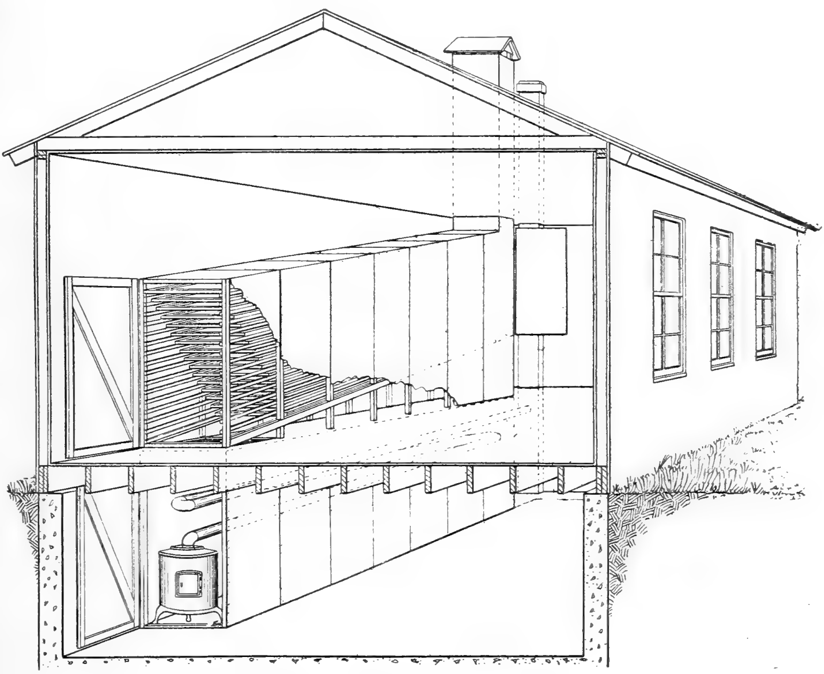

FIG. 6.—A 1-tunnel evaporator.

length. The box has a solid floor except at the lower end, where there is an opening 3 by 2 feet which permits the entrance of warm air from the furnace placed immediately below the opening. A ventilating shaft 2 by 3 feet is placed at the upper end and extends through the roof to a height well above the top of the chimney and the peak of the roof.

The runways carrying the trays are made of strips 1 by 1 inch or 1 by 2 inches, nailed 4 inches apart to the studding on centers, thus accommodating 16 tiers of trays, one above another. The trays may be 2 by 3 feet or 2 by 4 feet, made of wire mosquito netting nailed to frames made of wooden strips 1 by 1 inch.

The trays of freshly prepared material are placed in the drier at the upper and cooler end and are gradually pushed toward the lower and hotter end as they become partially dried. When the drier is filled the edge of the tray on the lowest runway is placed flush with the edge of the hot-air opening, the next tray above projects about $2\frac{1}{2}$ inches over it, and so on to the top, as shown in figure 6. The arrangement at the opposite end is, of course, exactly the reverse. When thus arranged the edges of the trays act as baffle boards, breaking up the column of hot air arising through the floor and forcing it to pass between the successive tiers of trays. Any good-sized strongly constructed stove and any fuel which is available may be used. The arrangement of the pipe, as shown in the drawing, permits the maximum use of the heat produced by the fuel burned. The stove room may be temporarily partitioned off by walls of rough boards. Instead of a stove, a coil of steam pipe may be used for heating. The walls, floor, and ceiling of the drier may be of matched flooring, siding, sheet iron, or beaver board.

A drier of the size shown will provide a little more than 300 square feet of drying space and will accommodate approximately 700 pounds of wet seed at one charge. If all the wet seed which is produced in one day is left in such a drier overnight it will be dry the following morning. It is estimated that the entire cost of such a drier will not exceed $250.

The Bureau of Chemistry has developed and successfully applied the so-called trayless drier (fig. 7) to the drying of vegetable products. This drier consists of a tight wooden box in which a double series of dumping trays is mounted. The total drying area, consisting of 32 square feet, is divided into four compartments, 1 foot wide and 4 feet long, each being provided with two dumping trays, as shown in the illustration. The drier is made of white pine lined with compo board to prevent the leakage of air. The lower front of the drier is fitted with two doors, through which the finished material can be removed. The air is heated by a furnace and is supplied directly by a blower fan which delivers about 2,000 cubic feet of air a minute against a static pressure of a 1-inch water gauge. A furnace, such as is used for heating houses, is large enough for a drier of the size described. Where steam is available steam coils can be used for heating. Devices for charging the drier or for discharging the finished material are not shown, but could easily be constructed, thereby making the operation more or less automatic. The lower compartment could be made hopper shaped and fitted with a gate valve discharging the seed to a conveyor or oscillating apron. In operation the wet material is placed in the upper tray for about half an hour. The tray is then tilted and the charge is dumped to the tray below and a fresh charge put into the

upper tray. When the seed in the lower tray is dry the latter is tilted and the batch dumped into the hopper bottom. This process is then repeated.

This drier will satisfactorily dry unwashed seed at the rate of 130 pounds of wet seed an hour, or approximately 1,000 pounds a day. Washed seed, however, can be dried more quickly. The drier could easily be built by a carpenter in a few days, and the cost for material,

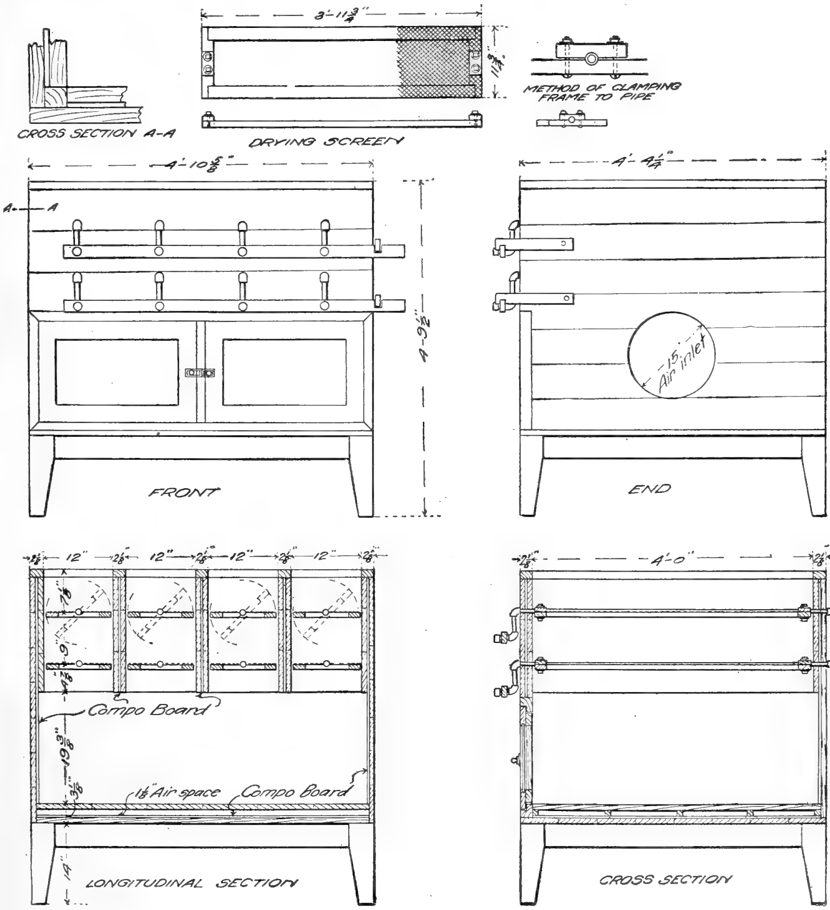

FIG. 7.—A trayless drier.

using ordinary building material, would be approximately $40. One hundred dollars would doubtless cover the entire cost for labor and material. The cost of a fan would be approximately $50, while a heater and piping would add about $100 more.

Considerable attention was directed to the performance of the rotary type of direct-heat drier. It might be thought that the preliminary mechanical reduction of moisture from 65 to 50 per cent is

so slight that the extra handling would be unprofitable. However, such treatment seems to be necessary in order to make the subsequent drying by the rotary drier successful. If the seed contains more than 52 to 55 per cent of moisture, it has a tendency to pack and stick to the walls of the drier instead of drying and discharging freely. In the experiments conducted none of the expeller or centrifuged seed packed in the drier, but in every case the untreated seed did pack.

An experimental direct-heat drier (fig. 8) was installed for the work, the heat being supplied by gas. The seed-drying chamber of this machine was 5 feet long by 1 foot in diameter and rotated at

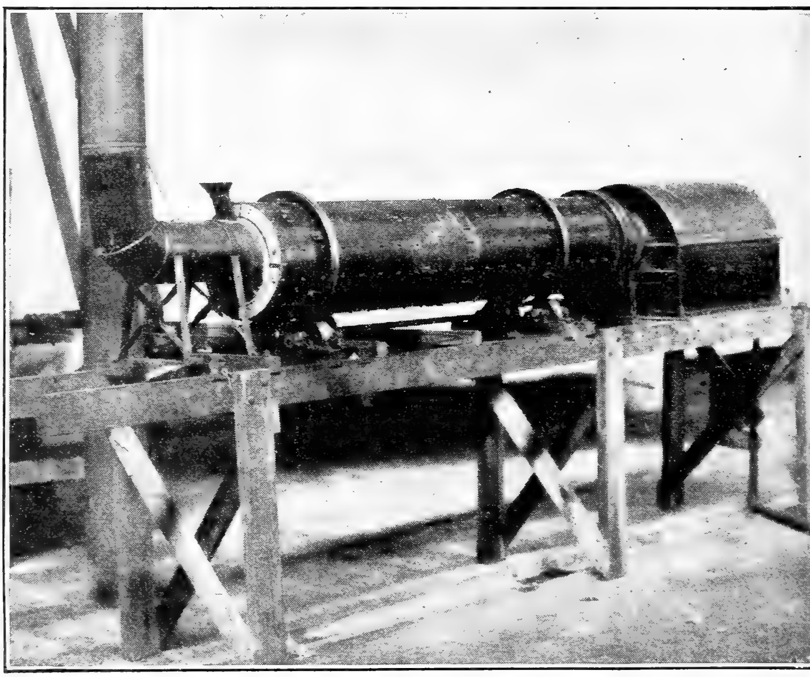

FIG. 8.—An experimental direct-heat drier.

the rate of 16 revolutions per minute. About six or seven minutes were required for the seed to pass through the machine. Inasmuch as this period was too short for complete drying, several passages through the drier were necessary. Trials on a semicommercial scale demonstrated that such a machine is readily adapted to the drying of such material as washed tomato seed, since it is easily controlled, is continuous in operation, and carries a minimum labor charge because it requires but little attention.

In order to produce seed of proper dryness it was necessary to pass it through the machine three times. The moisture content, which at the beginning was 52.4 per cent, at the end of each passage

was reduced, respectively, to 35.6, 21.9, and 9.6 per cent. In a fifth passage through the drier the moisture was reduced to 3.1 per cent.

It is, of course, apparent that a large commercial drier of this type (fig. 9) would be materially longer than the experimental drier, and probably one passage of the seed through the machine would reduce the moisture to about 10 per cent, which would be sufficient for subsequent oil extraction.

It is thus evident that one workman could handle the whole operation of seed treatment from the seed-washing cyclone through the moisture expeller and drier to the storage-bin conveyors.

THE USE OF EXHAUST STEAM COMPARED WITH LIVE STEAM.[5]

The advisability of using exhaust steam for heating the air with which to dry the seed depends (1) upon the other uses to which the available steam might be put and (2) upon the cost of producing live steam. Data from seed-drying plants show that with air heated to about 185° F. delivered at a rate of 2,000 cubic feet per minute the seed from a 5,000-basket pulping station may be dried in an eight-hour day. The quantity of steam necessary for this heating is 250 pounds an hour.

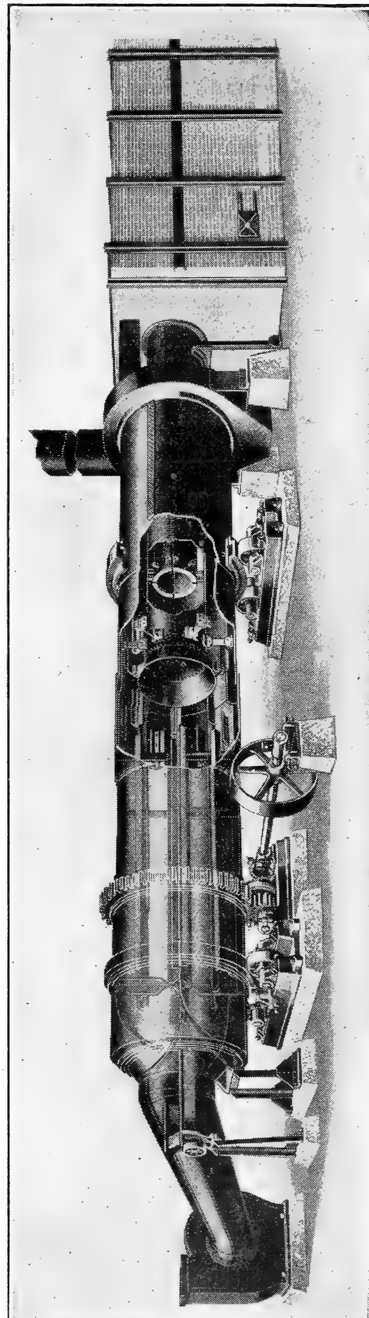

FIG. 9.—A commercial direct-heat drier.

[5] Contributed by J. C. Smallwood, Johns Hopkins University.

With steam at 50 cents a thousand pounds, which probably is as low as could be obtained at the present prices for fuel and labor, the total cost for heating the air during a season of, say, 50 eight-hour days would be $50.

Table IV shows the size and character of the equipment required for exhaust and live steam, respectively.

TABLE IV.—*Comparison of the size and character of the respective equipments required for exhaust and live steam in drying tomato seed.*

Equipment.	Exhaust steam.	Live steam.
Size of pipe line	1½ inches	½ inch.
Length of pipe line	Probably greater	
Accessories	Oil separator	Trap.
Heating surface of radiator	Same, if	Reduced pressure with reducing valve is used.
	Greater, if	Full steam pressure is used.

The cost of these installations will vary in every plant. It should be noted, however, that if there is a small engine near the drier, all or part of its exhaust steam may be piped to the radiator and allowed to flow through it continuously without the use of a trap.

Allowing 6 per cent for interest on the investment and 12 per cent for depreciation, etc., an increased expenditure of as much as $275 for equipment for the use of exhaust steam over that for live steam would be justified. If the cost of live steam is more than 50 cents a thousand or the season longer than 50 days, even a greater expenditure would be justified, with a possible increase in saving.

EXTRACTING THE OIL FROM TOMATO SEED.

Two methods are used for extracting oil from oleaginous seeds—pressure and solvent extraction.

The apparatus best suited for extracting oil by pressure is the expeller type of press (fig. 10), which is admirably adapted for pressing seeds that contain from 18 to 20 per cent of oil. A description of this press is unnecessary, since by its wide use in the oil-seed trade it has already become more or less familiar.

To test the effect of the expeller in the extraction of tomato-seed oil, seed under varying conditions was passed through the machine, as follows: One lot of seed was washed, dried, and handled in the usual manner; another lot was allowed to ferment in its own moisture for about five days, since it was recognized that much of the seed which would be assembled at the utilization centers would perhaps be in varying stages of spoilage. One lot of seed which had heated in storage because of previous insufficient drying was redried and passed through the expeller. Another lot consisting of uncleaned fresh seed with quite appreciable quantities of small pieces of skin attached was dried and pressed. The results of the expeller tests of these various lots of seed are shown in Table V.

TABLE V.—*Expeller tests of various lots of tomato seed dried in rotary and tray driers.*

Kind of seed.	Weight of product (pounds).			Net results (per cent).	
	Seed pressed.	Oil obtained.	Foots.	Oil.	Oil and foots.
Rotary drier:					
Normal	67.5	10.25	Trace.	15.1	15.1
Fermented	50	8	1.75	16	19.5
Heated	73.25	10.25	Trace.	14	14
Uncleaned	20	2.75	Trace.		13.7
Tray drier:					
Normal	63.75	12.0	Little.		18.8
Fermented	81.25	15	1.75	18.4	20.6

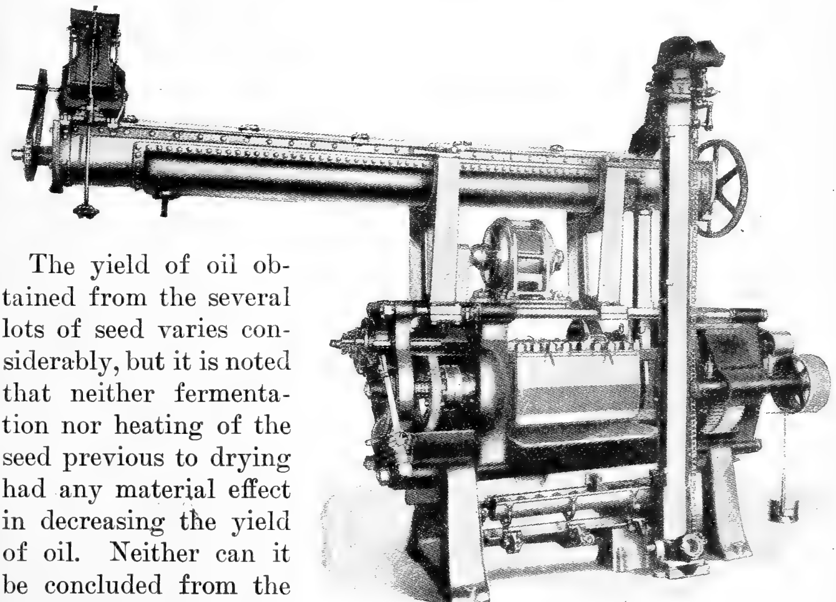

FIG. 10.—A commercial oil expeller.

The yield of oil obtained from the several lots of seed varies considerably, but it is noted that neither fermentation nor heating of the seed previous to drying had any material effect in decreasing the yield of oil. Neither can it be concluded from the results obtained that the seed dried in the tray drier produced a higher yield of oil than that dried in the rotary drier. The apparently higher yields are explained by the fact that before the tray-dried seed was run through, the expeller had been operated for several hours, thus causing a higher temperature, due to the heating of the barrel. Furthermore, the adjustments necessary for the efficient operation of the expeller with this particular material had been perfected when the tray-dried seeds were passed through. A yield of about 17 per cent of oil can therefore be expected from tomato seed by means of a perfectly adjusted expeller operating at its greatest efficiency.

In this connection, it may be stated that the oils obtained from the several lots of seed varied somewhat in color, from a pale golden yellow to a deep reddish brown. The lightest colored oil was obtained from heated seed dried in a rotary drier. This lot, however, gave the lowest yield of oil. The uncleaned seed yielded the darkest colored oil. Not enough difference was noted in either the yield or character of the oils to warrant the assumption that the heating or fermenting of seed, such as would probably take place in transit from the pulping station to the central reduction plant, would have an especially deleterious effect on the oil.

Solvent extraction of oil-bearing seed is at present receiving the attention of oil technologists, principally because of the higher yield of oil obtainable. It consists essentially of percolating the material with a suitable solvent which dissolves the oil and is subsequently recovered from the oil solution and from the residue by distillation. Benzol is perhaps the most satisfactory solvent used for this purpose at the present time. However, other solvents, such as gasoline, petroleum ether, and carbon tetrachlorid, are of value.

In the experiment made in the laboratory the seed was ground and extracted with benzol by maceration. The solution of the oil in benzol was placed on a steam bath and freed from the solvent by vacuum distillation. The yield of oil by this process was 20.7 per cent.

A modified method of solvent extraction is embodied in the so-called Cobwell process (fig. 11), which is being applied in garbage utilization and for other similar purposes. This process is applicable to oil-bearing materials with a high content of water. The process operates on the principle that when a wet mass is mixed with a volatile solvent and distilled the vapor tension of both water and solvent is lowered, whereby the mixture of the two vapors passes over into the condensing system. By renewing the solvent from time to time as the liquid mixture boils off it is apparent that the later distillates will become richer in solvent and weaker in water until practically all the water has been eliminated. Distillation is then stopped and the mass percolated with the solvent, whereby the oil is extracted and drained off with the solvent. This solution is pumped into a still and heated, which causes the solvent to vaporize and condense in an appropriate equipment, while the oil remains behind in the still.

It is apparent that this process obviates the necessity for seed separation, moisture reduction, and drying and at the same time yields the oil in one treatment of the raw waste.

The disadvantage of the process and of the one previously described is that both yield solvent oils, which bring a lower market price than pressed oils.

REFINING AND DEODORIZING THE OIL.

The tomato-seed oil obtained by the expeller process was deep brownish in color and possessed a strong odor. It was refined, bleached, and deodorized on a semicommercial scale by the usual method of procedure. After determination of the free acids in the oil a slight excess of caustic-soda solution (sodium hydroxid), about 16° Baumé (1.124 sp. gr.), was added gradually to the warm oil, with constant stirring. After thorough agitation the temperature was slowly raised to about 150° F. Under this alkali treatment an

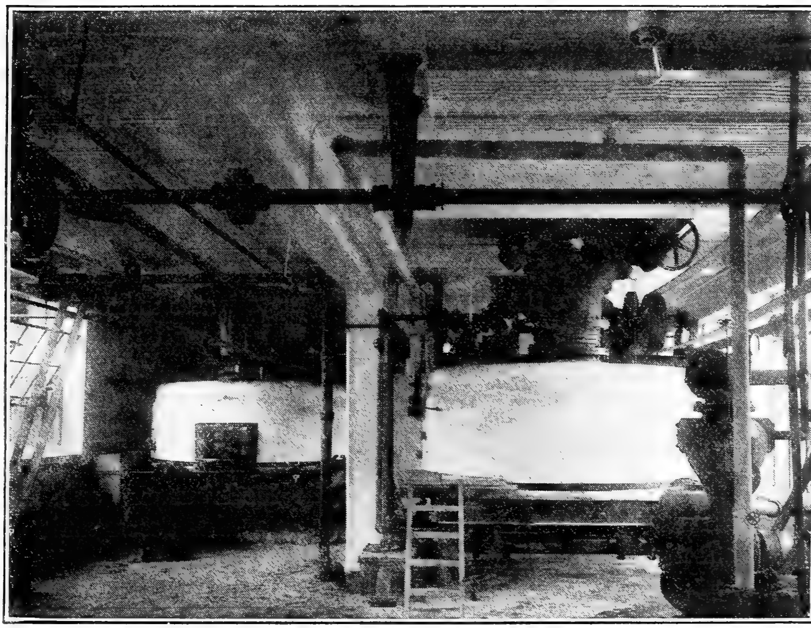

FIG. 11.—A commercial installation of the Cobwell process of solvent extraction.

excellent break was obtained. The precipitate was allowed to settle and the clear supernatant oil was drawn off. The oil was pale brownish red in color.

The optimum bleaching temperature was found to be 110° C., using 6 per cent XL fuller's earth and 3 per cent filtchar. The filtration was carried out in an ordinary laboratory filter press, using about 5 pounds pressure. The bleached oil had the appearance of virgin peanut oil. Deodorization was accomplished by passing a current of steam through the oil at an atmospheric pressure at 105° C. for 2 hours. The resulting oil was excellent in quality. Deodorization in a vacuum in modern improved apparatus would doubtless pro-

duce an oil comparable in quality to the common edible oils of commerce.

The solvent-extracted oil, which had an acidity of 1.55 per cent, was refined by using 16° Baumé sodium-hydroxid solution held at 28° C. for about 25 minutes, then heated slowly to 45° C. during a 15-minute interval. After standing several hours the clear oil was decanted, slowly heated to 120° C., and treated with 6 per cent of a good grade of fuller's earth which had been previously heated. Deodorization of this oil was carried out at 200° C. under a vacuum of 27 to 28 inches for two hours. The colorimetric readings of the refined and bleached oil made with a Lovibond tintometer in a half-inch cell were 17.0 yellow and 1.6 red. The finished oil appeared to be equal to that obtained by pressure and gave readings in the standard cell of 18.5 yellow and 2.4 red. It would seem, therefore, that a very satisfactory grade of tomato-seed oil can be produced by solvent extraction, since the oil yields to refining, bleaching, and deodorizing equally as well as the pressed oil.

OIL CAKE AND MEAL.

The value of the oil cake or meal as a stock food has been demonstrated in Italy, where the utilization of tomato waste is in practical operation. An analysis of tomato-seed meal shows the following composition: Moisture, 7.15 per cent; ash, 4.64 per cent; protein, 37 per cent; nitrogen-free extract, 29.1 per cent; and fiber, 22.1 per cent. This analysis compares favorably with several of the better known meals of commerce, as shown in Table VI. The meal or cake possesses value not only as a cattle food, but also as a hog and chicken food. The slightly bitter taste which accompanies it can be effectively masked when used as a mixed stock food.

TABLE VI.—*Composition of various commercial stock feeds compared with that of tomato-seed meal.*

Feeding stuff.	Constituents (per cent).					
	Moisture.	Ash.	Protein.	Nitrogen-free extract.	Fiber.	Ether extract.
Tomato-seed meal	7.15	4.64	37.0	29.1	22.1	....
Cotton-seed meal	7.8	6.6	39.8	27.4	10.1	8.3
Sunflower seed (prime)	10	4.2	34.8	21.8	10.9	18.3
Sesame oil cake	9.8	10.7	37.5	21.7	6.3	14
Palm-nut cake	10.4	4.3	16.8	35	24	9.5
Rape-seed cake	10	7.9	31.2	30	11.3	9.6
Linseed meal (new process)	9.6	5.6	36.9	36.3	8.7	2.9

COMMERCIAL PROCEDURE FOR UTILIZING TOMATO WASTE.

In any commercial utilization project the cost involved in handling and reducing the material largely determines its profitableness, and the quantity and condition of the waste handled are important considerations.

Since no one pulping plant is likely to produce enough seed to make it practicable to install the equipment necessary for crushing the seed for oil, the most logical procedure, it seems, would be to assemble the seed from the various pulping plants at some central point where the necessary machinery could be installed.

To get the seed to a central plant two courses are possible: (1) To separate the seed at the pulping stations and send it to the utilization center for drying, or (2) to separate and dry the seed at each of the pulping stations.

In the first case, where the wet seed is shipped directly to the central plant for drying and crushing, several points are to be considered. The seed as it comes from the machine contains from 65 to 70 per cent of moisture; hence, to assemble the wet seed at a central plant would involve a heavy freight charge for hauling the moisture.

The profits might be great enough to bear this expense if the place for assembling the seed was not so far away from the producing centers as to consume too much time in transit, on account of the rapidity of spoilage of the seed. Also, if shipped in less than carload lots, there would be an increased freight charge. Since a 5,000-basket plant produces only about three-fourths of a ton of wet seed a day, fully three weeks would elapse before a minimum carload shipment (15 tons) could be ready. It has been found that spoilage over a short period does not deleteriously affect the yield or quality of the oil, but a long period would doubtless result disastrously. Stations within a short hauling distance of the utilization center could, of course, ship the wet seed.

At smaller plants which produce less seed or which are situated at greater distances it would be necessary to dry the seed before shipment. Local conditions, therefore, would determine whether the product of a given plant should be dried or shipped wet.

Where the wet seed is shipped directly to the central plant to be cleaned and dried, there should be proper and sufficient equipment to handle the material readily as it arrives. It would be necessary to have a conveyor to unload it from the car directly to the storage bins. Thence it should go by means of chutes directly to the washing cyclones, which should be of sufficient number and capacity to handle as much seed as is produced by all the contributing pulping stations at their peak production, which comes during the last week of August and the first two weeks of September. In washing the seed it should be mixed with about 8 or 10 times its weight of hot water and pumped by centrifugal pumps directly into the washing cyclones, whence it could be delivered to a conveyor which would carry it to the hopper of the moisture expeller. It might even be possible to eliminate the cyclone washing of the seed by pumping it into a bin with ample drainage and thence delivering it directly to the moisture expellers.

From these machines the seed would be conveyed directly to the rotary or the tray driers and thence into the storage house. The whole operation would thus be continuous, and labor would be kept down to a minimum.

It is understood, of course, that this portion of the plant would operate only during the pulping season. If the oil were to be extracted at this central point, oil expellers could be installed and the seeds crushed during the winter months.

To handle this material it would be necessary for some operating company to install a plant at some central point, as suggested above. Preferably all the seed-separating machines installed at the various pulping stations should belong to the operating company and be assigned to the local concern, the cost being charged against the investment. The matter of credits to the pulping plants for seed contributed could be established by buying on a tonnage basis figured as wet or dry seed, as the case warranted.

As an alternative there could be a cooperative holding company consisting of all the seed producers, who would handle the seed to the drying stage and then either install an oil mill for pressing it or contract with a regularly established oil mill to make the crush. In any event the profits would be divided among the stockholders (cooperating firms). This would insure the necessary tonnage of seed supply and at the same time involve the use of but little machinery outside of that regularly used in a pulping station. It is recognized that the individual profits would be small, but withal far more than are now realized, for in most cases the seed is now an actual expense. It is even suggested that there be a national association of the canners to operate the plan, thus profitably utilizing another waste material, as is already being accomplished in many other lines of canning and packing.

The second plan involves no central utilization plant as such. Under this plan seed-separating cyclones would be installed at every pulping station, together with a drier, preferably the tray drier previously described, on account of its more adaptable size. Since it costs but little more to operate a large than a small drier, it would probably be best to install one large enough to handle the entire output of a given station within two or three days. By this plan the seed would be allowed to accumulate for that length of time and would be dried at once, thus reducing the cost of labor to three days a week. The individual plant would be under no charge for cyclone or drier, as these would be installed by the operating company and the initial cost of installation would be borne by the capitalization. If made in lots of 25 or 50 of standard pattern, the cost of the driers would be reduced to a minimum. The dried seed could then be shipped when convenient to some central regularly

operating oil mill, which would crush it either on a pro rata basis or on a flat contract, depending on the arrangements effected.

If the Cobwell system of extraction be adopted, the wet seed would have to be accumulated at a central point, since the drying and extracting are done at the same time. The operation of such a plant would necessarily cease with the packing season unless other material could be obtained for oil extraction. It has been suggested that butcher's trimmings, which are produced in the largest quantities mostly during the winter months, would supply the plant with material between seasons.

COST OF HANDLING THE WASTE.

In determining the approximate cost of a utilization project of this character it is necessary to consider the expense involved in all the operations from the assembling of the seed to the manufacture of the oil and press cake. This latter would, of course, involve the cost of the plant and equipment.

SEPARATING THE SEED.

As previously stated, the cost of seed separation is negligible, since in ordinary practice one man can operate three or four, or sometimes even six or eight, cyclone machines, depending on the character of the layout. Since a 5,000-basket plant usually operates two pulping cyclones, a single cyclone for separating the seed can readily be operated with no extra labor charge.

ASSEMBLING THE SEED.

If the pulping station is located in a city or in any place from which seed or other waste must be hauled away, the cost of assembling such seed for shipment would place no financial burden on the recovery operations, because in either event a hauling charge would be necessary. If, on the other hand, the station is located in the country, where no hauling charge is involved, there would be the necessary cost of loading the seed on a car for shipment to the utilization center.

To ascertain the most satisfactory place for a central plant, data on freight rates were collected, showing the cost of delivery of seed to each of the following places: Philadelphia, Pa.; Westfield, N. Y.; Chicago, Ill.; and Indianapolis, Ind. If all the seed were shipped to one central point, the most likely center would be Westfield, N. Y., for the East, and Indianapolis, Ind., for the Middle West; but if the operation were to be conducted in a more or less restricted area, then the cheapest freight rates would, of course, group about the nearest center.

At present there is no oil mill located at Westfield, N. Y., but this point is included, together with Chicago, Indianapolis, and Philadelphia, in the estimates on freight charges.

The cost of assembling the seed at the various suggested utilization centers, together with the approximate quantity of seed produced, both wet and dry, in the several largest tomato-pulping States is given in Table VII. The figures for shipping wet seed are based on the rates charged for dry bagged seed. There is no classification for wet seed shipped in bulk, so it is to be assumed that such bulk rate would be no higher than the rates for shipment of dry seed in bags; hence, the freight cost of wet seeds as given is considered to be conservative.

TABLE VII.—*Cost of assembling wet and dry tomato seed at several possible utilization centers, together with the quantities of seed produced in the various States.*

Product and State.	Utilization centers.				Quantity of seed (tons).
	Chicago, Ill.	Indianapolis, Ind.	Philadelphia, Pa.	Westfield, N. Y.	
Wet seed:					
Delaware	$1,440	$1,300	$630	$1,050	96
Illinois	165	2,060	4,030	2,805	184
Indiana	3,400	2,055	6,860	4,182	616
Kentucky	135	90	229	170	15
Maryland	3,500	3,240	1,500	2,340	385
New Jersey	4,120	3,930	970	2,480	267
New York	1,980	2,000	850	900	147
Ohio	990	980	1,356	1,005	120
Pennsylvania	1,560	1,410	837	1,120	92
Unreported [1]	12,160	9,870	6,065	8,220	1,127
	29,450	26,935	23,318	24,272	3,049
Dry seed:					
Delaware	480	430	210	350	31
Illinois	55	480	935	660	61
Indiana	970	603	2,000	1,240	205
Kentucky	45	30	75	60	5
Maryland	1,170	1,080	500	780	130
New Jersey	1,070	995	305	665	88
New York	575	540	235	255	49
Ohio	265	260	365	280	40
Pennsylvania	415	385	200	320	30
Unreported [1]	4,050	3,290	1,860	2,740	375
	9,095	8,092	6,685	7,350	1,014

[1] Unreported firms are those who failed to respond to the request to furnish statistics of consumption. The estimates for these are based on general information.

The total cost of shipping wet seed to the several drying centers would average $26,000 for 3,000 tons (about 1,000 tons of dry seed). To ship the dry seed would cost about $7,800.

DRYING THE SEED.

Since it is necessary that the seed be dried either at each pulping station or at a utilization center, the cost of drying will have to be figured accordingly. For convenience, Table VIII is presented to show the number and size of the several pulping stations. In order to determine more conveniently the cost of drying the seed at each of the pulping stations, they have been listed according to their capacity.

TABLE VIII.—*Number and size of tomato-pulping plants in operation.*

Size of plant.	Number of plants.	Size of plant.	Number of plants.
Under 1,000 tons	20	6,000 to 8,000 tons	3
1,000 to 2,500 tons	24	8,000 to 10,000 tons	1
2,500 to 4,000 tons	7	Over 10,000 tons (17 units)	2
4,000 to 6,000 tons	5		

If the seed is to be dried at each of the pulping plants, a small tray drier (previously described) would be the most economical to install for the purpose. If a 4,000-ton plant, pulping 5,000 baskets of tomatoes a day, requires one drying unit (all the plants under 1,000 tons being eliminated from consideration), there would be 31 in this class (for fractions of a unit must be considered as a whole unit). The eight plants of the succeeding two classes would require 16 more units, while the plants in the last two classes would require proportionately more units, or about 20. On this basis the total number of drying units required for the several plants would actually be 67, but 70 is adopted to allow for possible fractional capacities.

EQUIPMENT FOR DRYING.

The cost of the necessary equipment, including the cyclone heating and drying units, together with the operating cost for drying the seed at the pulping plants, is approximately as follows:

	Estimated cost.	
Equipment:		
Seed-separating cyclone	$200	
Pump	50	
Piping	50	
Drier	100	
Fan	50	
Heater	100	
Housing	50	
Steam piping	100	
Total cost of equipment for one drying unit	700	
Total cost of equipment for drying at 70 pulping stations		$49,000

The cost of operation has been calculated as follows:

	Estimate.	
Operating costs:		
Depreciation, at 10 per cent	$4,900	
Labor (including shipping labor), 1 man at 40 cents an hour for 10 hours per unit (4×70×60)	16,800	
Power	4,200	
		25,900
Total cost		74,900

If the wet seed is to be dried at one central drying plant it would still be necessary to install at each pulping plant seed-separating cyclones. This wet seed after arriving at the drying center would be subjected to the operation of washing, expelling the moisture, and drying, the latter operation being conducted in rotary driers. Such a plant would operate 24 hours a day, handling the peak production of 50 tons of wet seed a day over a season of about 60 days.

The following equipment would be necessary for a plant of this kind:

		Estimated cost.
Conveyor to holding tank		
Tank and stirrer		
Piping to cyclones		
10 cyclones or tank and conveyor		
Conveyor to expellers		
4 moisture expellers		
Conveyor to driers		
5 driers		$60,000
Conveyor to bagging machine		
Bagging machine		
Piping, shafting, etc		
Boiler and engine		
Freight and incidentals		
Pump, traps, valves, etc		
Drilling well, etc		
70 cyclones at pulping stations, at $200 each	$14,000	
70 pumps, at $50 each	3,500	
Piping, freight, etc	10,000	
Incidentals	5,000	
		32,500
Total cost of equipment for drying the seed at a central drying plant		92,500

The cost of operation is estimated as follows:

Labor (loading wet seed into cars)	$1,600
Depreciation of plant, at 10 per cent	9,250
Labor, per day, $159.20 (approximate cost), for a season of 60 days	9,552
Management (manager at $3,500, clerk at $1,200), three months	1,175
Power (500 tons of coal at $8 per ton)	4,000
Total	25,500

A summary of the costs of assembling and drying the seed at a central drying plant and at the several pulping plants is given in Table IX.

After separating, assembling, and drying, the seed is ready for the extraction of the oil. The cost of this procedure will depend on the method of extraction employed, whether it be the expeller or the solvent method.

TABLE IX.—*Operating costs of assembling and drying seed at a utilization center and at the pulping plants.*

Cost.	Drying center.	Pulping plant.
Depreciation	$9,250	$4,900
Labor (including shipping)	11,152	16,800
Power	4,000	4,200
Management	1,175	1,175
Assembling (average)	25,994	7,806
Total	51,571	34,881

EQUIPMENT FOR EXPELLING THE OIL.

The same building which housed the cleaning and drying machinery during the pulping season could be equipped with oil expellers for crushing the seed during the winter months. For such a plant the following equipment would be necessary:

5 expellers, 1 sump tank, 2 conveyors, 1 filter press, 2 grinding mills, 3 pumps, 2 tanks, piping, and miscellaneous. The estimated cost is	$30,000

The operating cost for expelling the oil from 1,000 tons of dry seed, with the depreciation cost of the machinery and the labor and power charges at current rates, is as follows:

Depreciation of the plant, at 10 per cent	$3,000
Labor (1 mechanic, 1 engineer, 1 fireman, 2 laborers, and 1 foreman)	6,100
Power (600 tons of coal at $8 per ton)	4,800
Management (manager at $3,500, clerk at $1,200) for 9 months	3,525
Total	17,425

The installation of a solvent-extraction plant would probably cost about the same as an expeller plant, namely, $30,000.

The operating cost of extracting 1,000 tons of dry seeds is estimated to be as follows:

Depreciation of the plant, at 10 per cent	3,000
Labor	6,100
Power (500 tons of coal at $8 per ton)	4,000
Management	3,525
Total	16,625

The above operating costs for both expeller and solvent extraction are perhaps rather high, since the figures are based on the output of tomato seed only and represent but a comparatively short period of time, the equipment being idle for a large portion of the year unless something else, such as grape seed, pumpkin seed, or some other oleaginous material, can be worked during this idle period. In the event that other materials were worked, the overhead cost would be reduced accordingly and the profits augmented proportionately.

Since it is shown (Table IX) that the most economical operation is involved in drying the material at the respective pulping plants, the total handling cost of this utilization project would be the sum of the cost of preparing the seed and the manufacture of the oil by either the expeller or the solvent-extraction method, which is shown in Table X.

TABLE X.—*Comparison of the cost of tomato-seed utilization by either the expeller or the solvent-extraction method.*

Operation.	Expelling.	Solvent extraction.
Preparation of seed	$34,881	$34,881
Recovery of oil	17,525	16,625
Total handling cost	52,406	51,506

POSSIBLE RETURNS AND NET PROFITS FROM OIL, CAKE, AND MEAL.

In estimating the possible returns from the oil, cake, and meal obtained from the seed, a price of 16 cents a pound for expeller oil and 14.5 cents a pound for extracted oil was used as the basis of calculation. The value of the oil cake was estimated on the basis of $40 a ton, or 2 cents a pound, and the solvent-extracted meal at $30 a ton, or 1.5 cents a pound.

The gross and net returns from oil, oil cake, and meal from 1,000 tons of tomato seeds manufactured by the two processes described and yielding 17 and 20 per cent of oil by expression and solvent extraction, respectively, are shown in Table XI.

TABLE XI.—*Estimated gross and net returns from tomato-seed oil, cake, and meal obtained by either the expeller or the solvent-extraction process.*

Products.	Quantity (pounds).	Price per pound (cents).	Value.	
			Expeller.	Solvent extraction.
Oil	340,000	16	$54,400	
Do	400,000	14½		$58,000
Cake	1,660,000	2	33,200	
Meal	1,600,000	1¾		28,000
Total gross returns			87,600	86,000
Cost of oil recovery			52,406	51,506
Net returns			35,194	34,494

It is estimated that an oil-extraction plant will handle the entire tomato-seed waste in two months, which, added to the three months of the operating season during the summer when the seeds are collected and prepared, represents five months' operation throughout the year. The above profits, therefore, which represent an operating season of five months, could be increased by extending the opera-

tion to other materials, thereby decreasing the overhead charges and adding to the profits already accrued. A plant equipped and operated by an association of canners or packers would have sufficient waste materials of various kinds from the different canning operations to enable it to run throughout the year, thereby reducing the overhead charges and increasing the profits very materially.

SUMMARY.

It has been shown that the waste from the pulping of tomatoes accumulates in vast quantities at the various pulping stations in the eastern and middle-western tomato belts. This material is at present entirely wasted, and in many cases its disposal entails considerable expense to the producers.

Investigation of the practicability of utilizing this waste shows that by the application of proper methods the seeds may be separated from the waste and made to yield oil and press cake or meal of considerable commercial value, the former as a table or culinary oil and the latter as stock feed.

From the estimates made on the cost of separating, assembling, drying, and crushing the seed, together with the cost of the necessary equipment, considerable profit is indicated from an undertaking based on the utilization of this waste.

The most feasible and economical method of procedure apparently lies in separating and drying the seed at the various pulping stations and shipping it to a utilization center, where the commercial products can be manufactured.

A cooperative plan of manufacture by an association of canners and packers of which practically all tomato-pulping concerns are members would perhaps be the most feasible method for the practical utilization of the waste, not only from tomatoes but from other products as well.

With the growth and expansion of the industry from year to year, the returns from an undertaking of this character would be augmented in proportion to its growth, since the quantity of waste is dependent upon the annual output of tomato products.

The utilization of an agricultural waste of this character for the production of commodities of much commercial value is suggested as a conservation measure worthy of careful consideration.